A CONODONT ASSEMBLAGE FROM THE CARBONIFEROUS OF THE AVON GORGE, BRISTOL

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ABSTRACT. A fused assemblage of four apatognathids and one *Spathognathodus scitulus* is described and illustrated. It was collected from relatively unfossiliferous carbonates from the D Zone of the Avon Gorge, Bristol. Only two of the apatognathids are closely similar. The others are of different sizes and represent different species. The assemblage is interpreted as the remains of a single conodont-bearing animal and this is supported by a consideration of other assemblages, the rarity of conodonts in strata above and below those yielding the present assemblage, and the similar occurrence and stratigraphic ranges of the components in this and other localities.

THE recent growing interest in the value of conodonts in problems of stratigraphic correlation is based largely upon the study of discrete specimens which have been isolated from a carbonate matrix by digestion in dilute acid. In spite of the value of these individual conodont 'species' there has long been a realization that different individual forms of conodont may have been combined together within the body of a single animal. This possibility was first suggested by Hinde (1879, p. 361) who described what he thought to be a natural association of conodonts from the Devonian Genesee Shale of New York. He argued that the intimate association of a large number of different types of conodont on the bedding plane of the shale implied their original association.

Although this particular group is probably not a true natural assemblage (see Rhodes 1962, p. *W*71 for details), other workers have described associations of conodonts, which are accepted by most workers as original 'natural' (i.e. biological) assemblages. Most of these are from black fissile shales of the Carboniferous of North America and Europe (Schmidt 1934, 1950; Scott 1934, 1942; Dubois 1943; Schmidt and Müller 1964; Rhodes 1952, 1954, 1962). A full discussion of the arguments for regarding these as natural assemblages is given by Rhodes (1962, p. *W*72).

Other less well-documented Carboniferous assemblages are described by Cooper (1945) and D. J. Jones (1956, p. 126).

Two other methods of recognising original associations of conodonts have been developed within recent years. Rexroad and Nicoll (1964), Klapper (in Rexroad and Nicoll 1964), and Barnes (1967) have described fused conodont assemblages from Ordovician and Silurian strata, in which individual conodonts are fused to others of similar form. In some cases, e.g. Rexroad and Nicoll (1964), the fused elements are all of the same size and belong to the same form species; in others, e.g. Barnes (1967), they are of the same form genus, but represent individuals of different size and different form species. Barnes, Rexroad, and Nicoll have discussed at length the basis for regarding these fused specimens as natural associations.

Other workers have recently attempted to recognize original associations of conodonts by analysing the statistical distribution of individual species in large samples of isolated conodonts, e.g. Walliser (1964), Bergström and Sweet (1966), and Webers (1966).

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These studies have involved strata of Ordovician and Silurian age in which, if the inferences as to natural assemblages are correct, the arrangement of individual conodonts is rather more simple than that found in Carboniferous assemblages.

During a recent study of lower Carboniferous conodonts (Rhodes, Austin, and Druce 1969) a group of fused conodonts has been recovered from a typical light grey, fine grained calcarenite of the D Zone of the Avonian at the Avon Gorge, Bristol (ST 564734, sample D7, in the above study). 6 kg. of the rock was processed in acetic acid and a heavy mineral separation in bromoform of the dried residue produced a total of nine conodonts referable to the genera *Apatognathus*, *Hindeodella*, and *Spathognathodus*. Five were originally fused together as an assemblage, but one specimen became detached in preparing the specimen. The assemblage is deposited in the collection of the Department of Geology, University of Southampton (Catalogue number 10412).

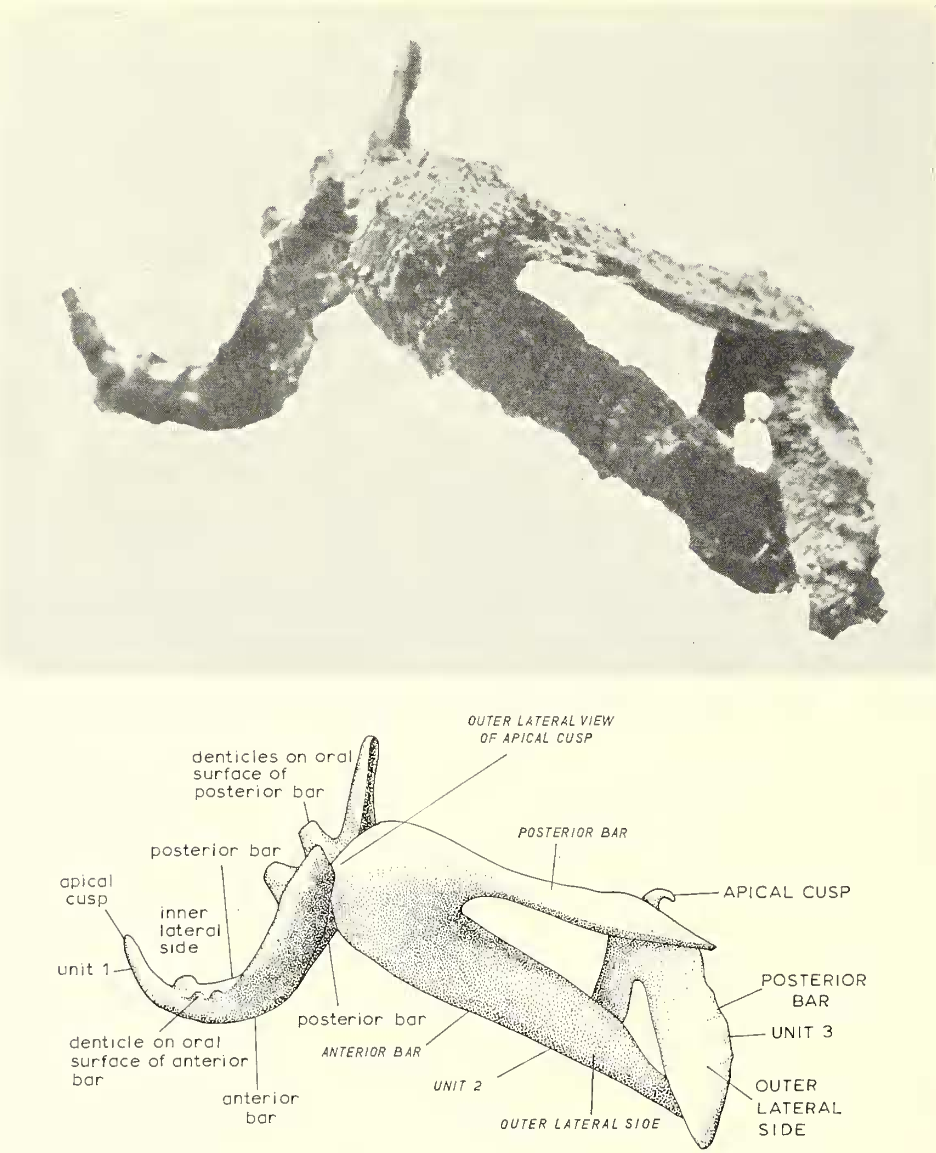
Description of the assemblage

The assemblage consists of three specimens of the genus *Apatognathus* Branson and Mehl and a single specimen of *Spathognathodus scitulus* (Hinde). The arrangement of the specimens is illustrated in text-fig. 1. This may or may not be the original biological arrangement. The biggest of the three apatognathids (unit 2) is orientated so that its anterior and posterior limbs both lie in a horizontal plane. The posterior bar lies nearest to the observer when seen in text-fig. 1. Its apical denticle region is fused to the anterior distal end of unit 1, the most anterior of the three *Apatognathus* specimens. This specimen is oriented at right angles to the plane of the posterior bar of the biggest specimen, and it faces in a position directly opposed to it. The third specimen of *Apatognathus* (unit 3) lies near the distal end of the posterior bar of unit 2, and is also arranged at right angles to it, both in a horizontal and vertical plane. This specimen, however, points directly posteriorly so that its denticles point in the direction of the distal end of the posterior bar of unit 2. The small specimen of *Spathognathodus* parallels the apical denticle of the *Apatognathus* (unit 2.).

The *Apatognathus* elements show individual differences. The anterior and posterior apatognathid elements of the assemblage tend to resemble one another in overall size and form. It is difficult to identify these in terms of existing species of *Apatognathus* but they resemble *Apatognathus chauliodus* Varker and *A. cuspidatus* Varker. The biggest *Apatognathus* unit possibly represents a distinct species.

The fusion of the four specimens with one another is very strong, and seems to be a result of additional material having the same appearance as that from which the conodonts are made. There seems to be 'fusing material' in direct and continuous contact with the opposed surfaces on the conodonts, but although we have looked at the assemblage under the highest magnification which we can obtain by use of optical microscopy, we have been unable to see any detail of this material.

One remarkable feature of the present specimens is the fact that they are preserved in such striking three-dimensional relief. They show little, if any, effect of compression. The two most striking features of the assemblage are the opposed position of the three elements at right angles to one another, in both a horizontal and a vertical plane, and also that in each case the distal end of one of the bars is fused to the apical end of its neighbour. It seems improbable that this is wholly fortuitous, but it is quite unlike the parallel and common alignment which is characteristic of all other known assemblages.



TEXT-FIG. 1. Stereoscan photograph and drawing of assemblage of *Apatognathus* and *Spathognathodus scitulus*. For details see text. Unit 1 is labelled in lower-case letters, unit 2 in upper-case italics, and unit 3 in upper-case roman. Magnification ×70 approx.

Systematic palaeontology

Specific identification of the hindeodellid fragment is impossible. One of the isolate apatognathids is compared with *A. petilus* Varker, another is fragmentary and specifically indeterminate, and the remaining two, which are similar, are well preserved, but juveniles. They do not agree exactly with any descriptions or illustration of existing species, though they show some resemblance to *A. cuspidatus* Varker. They differ most conspicuously from illustrations and descriptions of this species, however, in the relative length of the apical denticle, and in the degree of lateral twisting of the anterior and posterior bars. This is so extreme that the denticles curve upwards towards each other and the centre of the arch, away from the plane of the anterior and posterior limbs. The apical angle is extremely acute and in this it resembles *A. cuspidatus* as well as *A. chauliodus* Varker.

One of the specimens (unit 1) fused in the assemblage, appears to represent the same species as the two free specimens just described, but it is a somewhat larger individual and it has a longer apical denticle than either of the other specimens.

Interpretation of the assemblage

We regard our specimen as a natural assemblage not only because of the enormous improbability of any artificial association of this kind within samples which have been subjected to such relatively violent disaggregation, but also because of other occurrences of a similar kind of fusion in what are to us clearly natural conodont assemblages (Rexroad and Nicoll 1964, Barnes 1967). The association must, in our view, clearly be 'original' in the sense that it represents a pre-depositional association. The rarity of conodonts in this sample seems to make it wholly improbable that it could be regarded as a fortuitous sedimentary inorganic association, which occurred after the death of the conodont bearing 'animal'.

It may then be asked what type of association this could represent if it is accepted as an original biological association. It may represent some kind of pathologic condition, in which elements normally freely associated together within a single animal, have become abnormally fused together. This also seems to be the most acceptable interpretation of the specimens described by Rexroad and Nicoll and by Barnes. Rexroad and Nicoll interpreted a similar association as a possible case of tetanus, but this may be to read more into the association of the conodonts than is justified. It seems unlikely however, in view of the very great rarity of other fused specimens, that this could have been a 'natural' condition.

A striking feature of the present assemblage is the difference in size between the elements that are associated together. It might be argued that the association of elements of such very different sizes is against their original association in a natural assemblage, but a fused assemblage from the Ordovician Coburg Formation of Ottawa (Barnes 1967), contains an association of belodids, which show a comparable variation in individual size. Barnes argues that this association may suggest either a process of continuous replacement within a natural conodont assemblage or the original association of strikingly similar conodonts of different sizes. Either interpretation could be applied to the present group of apatognathids.

In contrast to this most of the elements in known Carboniferous conodont assemblages are of almost identical size and seem, therefore, to have been directly paired. It could be that *Apatognathus*, which is a genus with a very irregular occurrence, did not represent a similar type of paired component in a natural assemblage and Cooper (1945) has argued that at least some Carboniferous assemblages may have contained unpaired components. Other workers (Schopf 1966, Webers 1966, Bergström and Sweet 1966) have suggested that Ordovician assemblages were probably composed of different types of individual components from those of Pennsylvanian age. The present assemblage cannot therefore, be interpreted only by comparison with known Pennsylvanian assemblages (Rhodes 1952).

It is difficult to compare the present conodont fauna of the assemblage with any immediately adjacent to it, because from samples collected at 10 ft. intervals from 200 ft. of strata immediately below and from 50 ft. immediately above the present sample no conodonts have been recovered. It is noteworthy however that the genus *Apatognathus*, which is not known to form more than 25% of faunas of broadly similar age in other areas, constitutes 77% of the fauna of the present sample. Both the rarity of conodonts in over 250 ft. of strata (138 kg. of which were digested in acid) and the relative rarity of *Apatognathus* elsewhere support the possibility that the assemblage may be an original biological association. The strong nature of the fusion of the elements, also seems to us to favour such an interpretation.

As noted above, studies of some Silurian (e.g. Walliser 1964) and Ordovician (Bergström and Sweet 1966) faunas have shown a constant numerical relationship and identical stratigraphic range between certain isolated conodont 'species'. These have been interpreted as assemblages.

We have compared the relative abundance of individual components of our assemblage, when they occur as isolated conodont elements in strata of comparable age in the North Crop of the South Wales coalfield, the Avon Gorge, Bristol, Yorkshire, and Scotland. Comparison of the percentage frequency of all isolated apatognathids with *S. scitulus* provides no consistent ratio between them, individual samples ranging from 1:2·50 to 1:0·20. Similar variable ratios are also found in other individual samples of very large conodont faunas from which assemblages have been recognized (e.g. Schopf 1966, Webers 1966). Most authors attribute this to post mortem sorting (e.g. Schopf 1966, p. 16).

The stratigraphic ranges of *S. scitulus* and *Apatognathus* are similar in each area from which they have been recovered. Also *S. scitulus* and *Apatognathus*, though both relatively rare, are most frequently found in the same sample. This common association is also present in the Viséan rocks of North Wales (Aldridge, Austin, and Husri 1968).

We interpret the common association and similarity of stratigraphic range of *S. scitulus* and *Apatognathus*, when found as isolated elements, as support for the suggestion that they were originally associated together as a biological assemblage.

CONCLUSIONS

A fused assemblage of four *Apatognathus* with a *S. scitulus* suggests that these elements were associated together in the same conodont-bearing animal. This interpretation is supported by a general consideration of the occurrence and preservation of the assemblage, comparison with other known assemblages, other common occurrences of the two components, and their generally similar stratigraphic ranges.

Variation in the size of the *Apatognathus* components of the assemblage suggests that there may have been a form of continuous replacement of components within the assemblage or, more probably, that different sizes of the same element were present.

The relative positions of individual apatognathids in the assemblage may or may not represent the original orientation within the conodont-bearing animal. It seems to us improbable that they do, for all described conodont assemblages from the Ordovician, Silurian, and Carboniferous display a broadly parallel alignment of associated elements.

The present assemblage throws little new light on the puzzling question of the affinity and function of conodonts.

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